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Technologies for the next generation of downsized gasoline engines

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ABSTRACT

Research and /or Engineering Questions/Objective:
Gasoline engine downsizing has been demonstrated to give significant reductions in vehicle fuel consumption and CO_2 emission levels by effectively moving the engine operating points for any given drive cycle to a more efficient region of the BSFC map. The limit to which downsizing can offer advantages to fuel efficiency therefore comes when the average engine operating points are centred around the minimum BSFC region.
To take downsizing further, a number of complementary technologies are being explored with the aim of increasing overall efficiency and extending the operating region of optimum efficiency. Additional benefits can be derived from secondary effects when technologies are combined.
This paper summarises such complementary technologies and discusses how they can be used in practice to further optimise gasoline engine efficiency.

Methodology:
This paper has been compiled from advanced research work conducted by MAHLE Powertrain, using data from its own 3-cylinder downsizing demonstrator engine and single cylinder research engines. The findings of other research work is also referenced where appropriate.

Results:
Results have shown that external cooled EGR can offer significant benefits to combustion processes at high loads, as well as de-throttling benefits at part load. The characteristics of alternative fuels can also offer some distinct advantages in highly boosted situations. Over-expansion cycles (ie, Miller and Atkinson cycle) offer thermal efficiency benefits, although effectively act to “up-size” engines, and application needs to be considered against the full range of engine operating specifications.

Limitations of this study:
This study explores individual technologies investigated with prototype hardware and simulation results. The extent of interactions and overlap between technologies has not been fully explored, and the challenges of putting technologies into mass production are not examined.

What does the paper offer that is new in the field in comparison to other works of the author:
This paper presents results from advanced research work conducted by MAHLE Powertrain. It also draws on development knowledge gained from MAHLE’s own 3-cylinder downsizing and the single cylinder research engines. This information is brought together to give a profound insight into the next steps that can be taken to further improve fuel efficiency of next generation gasoline engines.

Conclusion:
A number of complementary technologies exist that can be used either in isolation, or in combination to give specific benefits to the efficiency of gasoline engines. It is likely that many of these will become common in future automotive powerplants as demands for lower fuel consumption and CO_2 emissions further increase.